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UNITED STATES PATENT APPLICATION

FOR

DIGITAL COAXIAL CABLE LAN

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BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates generally to networking and more particularly to data distribution through a coaxial cable at frequencies that take advantage of the operating frequency spectrum of the coaxial cable so as to not interfere with the operating frequency of the client data within the coaxial cable.

Background Information

Conventional homes contain many electronic devices that generate data or operate on data received internally, from other devices, or from sources outside of the home. For example, content devices such as televisions, video cassette recorders, personal computers, and stereos as well as monitor and control devices such as climate-control devices, security devices, and home automation devices all generate or use data. In-home local area networks (LANs) may be used to distribute such data around the home, both to and from these devices.

As home based LANs become more popular for in-home networking, the ability to transmit high-bandwidth data including digital video remains difficult to implement. Several alternative mediums for in-home networking are known. For example, current solutions that do not require new wiring include AC power lines, telephone lines, and wireless communication. There are also options that require installing new wires such as CAT-5 twisted pair, fiber optic, and IEEE 1394 (fire-wire). In general, the solutions that do not require new wires suffer from low bandwidth or high cost. Solutions that require new wires suffer from being expensive as well as technology that has not been proven over time as compared to coaxial cables. Table I lists some of these alternative mediums with their limitations.

MEDIUM	LIMITATIONS
AC power-lines	Unregulated Low bit-rate (Harsh environment) Data security issues Perceived usage hazards
Telephone lines	RF interference RF emissions regulations
Wireless	Limited bandwidth Expensive Data security issues Transmission disruption due to movement
New wires	Installation costs Maintenance costs

Table 1: Alternative Mediums

Thus, there is a need to transmit data around the home and elsewhere in cost-effective, quick, and secure fashion.

SUMMARY OF THE INVENTION

The invention relates to a coaxial cable local area network (LAN) for digitally communicating client generated data between clients of the cable LAN. The cable LAN has adapters in communication with both the clients and other adapters of the cable LAN. Connected through coaxial cable, these adapters generate and communicate data transmitting signals that take advantage of the operating frequency spectrum of the coaxial cable so as to not interfere with the operating frequency of the client data within the coaxial cable. Other features are disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of an in-home coaxial cable LAN in accordance with an embodiment of the invention.

FIG. 2 is a schematic illustration of a coaxial cable LAN in accordance with an embodiment of the invention.

FIG. 3 illustrates an operating frequency of the client data and the adapter signal in accordance with an embodiment of the invention..

FIG. 4 is a schematic of an architecture of a cable LAN adapter in accordance with with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention discloses a coaxial cable local area network (LAN) for communicating data between clients of the cable LAN. The benefits of the cable LAN is the ability transmit data in cost-effective, secure fashion, without interfering with cable service company operations.

For purposes of explanation, specific embodiments are set forth to provide a thorough understanding of the present invention. However, it will be understood by one skilled in the art, from reading this disclosure, that the invention may be practiced without these details. Moreover, well-known elements, devices, process steps and the like are not set forth in detail in order to avoid obscuring the present invention.

Reference is now made to **Figures 1** through **4** to illustrate the embodiments of the invention. **Figure 1** is an illustration of an in-home coaxial cable LAN. As shown, drop cable **10** enters home **12** after it is tapped off main trunk **14** through cable service company splitter **15** within distribution box **16**. Near the point at which drop cable **10** enters home **12**, low pass filter (LPF) **18** is installed by the user, upstream of the in-home cable LAN network and downstream of any cable service company supplied low pass filter **20**.

A cable LAN isolator such as LPF **18** preferably is installed by the user downstream of cable service company splitter **15**, even when a low pass filter is provided by the cable service company as shown by low pass filter **20** in **Figure 1**. The need for such a device can be attributed to several operational limitations such as security, performance improvement of premise network, and legal compliance. Here, LPF **18** maintains security for the cable LAN, works to improve the

performance of the cable LAN, and prevents signals generated within the cable LAN from interfering with cable service company operations.

By restricting spurious signals or cable LAN signals to the premise of the user, LPF **18** maintains security by preventing such signals from getting back to the public cable network. Although LPF **18** is shown installed within the physical premise of home **12**, LPF **18** may be secured elsewhere to maintain security. For example, installing LPF **18** within a lock box external to home **12** would maintain security. LPF **18** will also reflect cable LAN transmitted signals back into the network of the cable LAN. Thus, where splitter **22** is located close to LPF **18**, the return loss characteristics of LPF **18** may be helpful in coupling the cable LAN signal power from one arm of splitter **22** to another arm of splitter **22**. This, in turn, would decrease the amount of power needed to transmit cable LAN signals and thus improve the performance of the invention. Moreover, by preventing signals generated within the cable LAN from interfering with cable service company signals within main trunk **14**, LPF **18** serves legal compliance requirements.

Depending on the type of cable system, LPF **18** will have different cut-off frequencies. For example, one cable system only requires that the low pass filter have a cut off frequency of less than 1000 MHz whereas older cable systems require that the low pass filter have a cut off frequency of less than 450 MHz.

Coaxial cable splitters permit more than one client to receive identical data by dividing the cable into two or more cable wires. Thus, from the point at which drop cable **10** enters home **12**, drop cable **10** is split by splitter **22** into different cable wires **24**, each cable wire **24** being routed to different rooms in home **12**. Within living room **26** of **Figure 1** is living room television (TV) **28** having set top box (STB) **30**. Set top box **30** includes boxes that provide interactive television through high speed

internet data access. Coupled between cable wire **24** and set top box **30** is cable LAN adapter **32**. Cable wire **24** is also routed to office **3~~2~~4**. Within office **3~~2~~4** is office personal computer (PC) **36** having an internet gateway. The internet gateway may be personal computer **36** having high speed access to the internet, where the high speed access may be achieved through the shown a cable modem **30**, as well as other connection such as asymmetric digital subscriber loop (ADSL) modem, an integrated service digital network (ISDN), a T1 line, and a multimedia cable network system (MCNS) cable modem. Coupled between cable wire **24** and personal computer **36** is a second cable LAN adapter **32**.

Cable wire **24** is also routed to bedroom **40** and to bedroom **46**. To communicate with cable LAN adapter **32** in bedroom **40** and bedroom **46**, cable wire **24** is further divided from splitter **22** by splitter **38** into two cable wires **24**. Within bedroom **40** is bedroom TV **42** having set top box **44.** Coupled between cable wire **24** and set top box **44** is a third cable LAN adapter **32**. Within bedroom **46** is bedroom PC **48** coupled to a fourth cable LAN adapter **32**. To complete the cable LAN network, cable wire **24** from splitter **38** is connected to cable LAN adapter **32** in bedroom **46**. The number and arrangement of rooms and clients in home **12** is not particular to an embodiment of the invention. Home **12** may have different rooms, in different numbers and arrangements, each having different clients.

Typical clients of the cable LAN network are shown in **Figure 2**. These clients may include digital TV set top box **50**, digital video cassette recorder (VCR) **52**, digital TV **54**, home control and monitoring hub **56**, wireless hub **58** with bridge **60**, personal computer **62**, and personal computer motherboard **64**. Bridge **60** of wireless hub **58** is capable of communicating with different wireless devices. For example, one such wireless device may be a remote-control device that can be used for multiple clients on the network such as PC's, set top boxes, and digital TV's.

As shown in **Figure 2**, client interface **66** couples cable LAN adapter **32** to a client. Adapter **32** serves to connect these clients to the network of cable wires **24**. Client interface **66** may be any suitable computer interface, such as a Peripheral Component Interconnect (PCI) adapter card, Universal Serial Bus (USB), or buses meeting the Institute of Electronic and Electrical Engineering standard for a high performance serial bus, IEEE 1394. Adapter **32** may also be coupled to a client by other techniques. For example, adapter **32** may be housed in a client of the cable-LAN network such as indicated by dashed lines **68** for PC motherboard **64**.

In the preferred embodiment, there is at least one cable wire **24** couple between a pair of adapters **32**. In tests run on signal attenuation due to cable length, coaxial cable wire **24** that totaled less than 1000 feet in length operated within acceptable attenuation loss limits. Longer lengths are possible and are a function of at least the hardware and software of adapter **32**.

The overall operation can be understood from **Figure 2**. In the overall operation, a first client, such as PC **62**, communicates digital data to a first cable LAN adapter **32** through client interface **66**. After processing the data for transmission, the first cable LAN adapter **32** communicates the processed data to a second cable LAN adapter **32** through coaxial cable wire **24**. On receiving the data, the second adapter **32** further processes the transmitted data to a form usable by a second client, such as digital TV **54**, and transmits that data to second client digital TV **54** through client interface **66**. First cable LAN adapter **32** may also communicate this same data to other adapters **32**, that, in turn, may transmit the received data to their associated client.

Figure 3 illustrates an operating frequency of the client data and the adapter signal. Coaxial cables are currently being used by data suppliers to communicated

data such as television and internet data to individual homes. These cables themselves are a very clear, clean medium capable of handling operating frequencies of up to 2000 MHz. However, most of this operating frequency spectrum goes unused by data suppliers since initially there was little need for frequencies higher than 450 MHz and, as need for higher operating frequencies slowly increased, costs to changing the infrastructure of the data suppliers became the prohibiting factor.

The lower region identified in **Figure 3** as 0-950 MHz is where conventional cable TV, digital cable TV, and cable modem services are offered. Where this is the case, the cable LAN signal operating frequency may be located within the higher region identified as 1000 - 2000 MHz at the center frequency of 1300 MHz with a bandwidth of 5 MHz. Here, the cable LAN utilizes the operating frequency spectrum not used by conventional cable services. The same is true for other forms of data such climate-control data, security data, home automation data, Moving Picture Experts Group 2 (MPEG-2) high resolution digital video data, audio data, or internet data.

In the preferred embodiment, a signal generated by adapter 32 downstream of LPF **18** rapidly transmits data from one adapter to another adapter as a carrier modulated digital signal. The carrier modulated digital signal may be generated in conjunction with using Quadrature Phase Shift Keying (QPSK) modulation typically employed on satellite technology. Since QPSK modulation operates at 2 bits per hertz, the signal speed would be 10 megabits per second (Mbps) for a 5 MHz bandwidth. Modulation is further discussed below.

A significant advantage of this invention is the large bandwidths that may be applied in transmitting data. For example, within the 1000 - 2000 MHz region

shown in **Figure** 3, bandwidths of 5 MHz, 10 MHz, 20 MHz, 50 MHz, or higher are possible. By using bandwidths larger than 5 MHz, the signal speed increases. With coaxial cabling, speeds greater than 100 Mbps can be achieved. Preferably, the signal speed will be greater than 10 Mbps when necessary to quickly distribute digital video and other types of high-bandwidth data within the home.

As depicted in **Figure 3**, the signal operating frequency could be anywhere above 1000 MHz. However, Cable LAN's operating region is not limited to this. For example, in older homes that use older type coaxial cable and older type splitters, normal cable operations are maintained below 450 MHz. In this case, the signal operating frequency of the cable LAN would preferably be between 600 to 800 MHz, but need not be. Since the signal operating frequency is subject at the lower end to the client data operating frequency, the signal operating frequency could be just at the border or fringe of the rated or actual data operating frequency being utilized within the coaxial cable. Operating at the border or fringe of the data operating frequency takes advantage of the operating frequency spectrum of the coaxial cable so as to not interfere with the operating frequency of the data, thereby permitting the signal and data other than that carried by the signal to be communicated within the coaxial cable at the same time, within the same space. Being adaptable enough to operate at this periphery of the data operating frequency makes the cable LAN flexible enough to operate on any coaxial cable system, despite the different limitations such as older network components, different geographies, different service providers, and different regulations. Moreover, since the signal operating frequency is subject at the higher end only to the operating frequency spectrum of the coaxial cable, the signal bandwidth may be much greater than 5 MHz, thereby increasing the signal speed. A 100 MHz bandwidth, for example, results in a signal speed of 200 Mbps. In this way, the large operating bandwidth makes the cable LAN

ideal for quickly transmitting high-resolution digital video (such as MPEG-2) and other high speed data.

Figure 4 is a schematic of an architecture of cable LAN adapter **32**. As seen in **Figure 4**, client software layers **70** is comprised of cable LAN protocol layers/stacks **72** and interface software/driver stack **74**. Analog or digital data from a first client is processed as necessary through that client's software layer into a digital format. This digitized data is then communicated to cable LAN adapter **32** associated with that first client for processing through the hardware sections of the cable LAN adapter. In accordance with an embodiment of the cable LAN adapter of the invention, cable LAN adapter **32** partitions into four hardware sections: I. MAC & Client Interface Section **80**; II. Baseband Section **90**; III. RF & Mixed Signal Section **100**; and IV. Medium Interface Section **130**.

I. MAC & Client Interface Section

As part of broadband application specific integrated circuit (ASIC) **78**, Media Access Control (MAC) & Client Interface section **80** operates both as a burst controller and as a protocol device to coordinate events -- such as when to receive the data from the client and when to transmit data to the client -- between the client and Baseband section **90** of cable LAN adapter **32**.

Client interface **76** is the front line communication link between adapter **32** and the particular client. Preferably, the client interface logic communicates with the client, communicates with the modulator, processes the particular data from the client and the modulator, and keeps track of time. Given the variety of clients that may occupy the cable LAN, it is important to utilize a universal client interface.

As shown in **Figure 4**, the hardware of client interface **76** may be a stand alone component coupled by coaxial cable between interface (I/F) core **82** of broadband ASIC **78** and the in/out (I/O) port of the client. Such stand alone components include a Universal Serial Bus (USB) attachment or attachments meeting the Institute of Electronic and Electrical Engineering (IEEE) standard for a high performance serial bus, IEEE 1394. Client interface **76** may also be integrated into MAC & Client Interface section **80** of cable LAN adapter **32** or housed into the motherboard of a client such as a personal computer (PC) or a set top box (STB). Moreover, through an expansion card such as a Peripheral Component Interconnect (PCI) adapter card, client interface **76** may be housed internally to adapter **32** or to a client.

If data copyright protection is a concern, client interface **76** can be coupled to a dongle security system key consisting of a serialized erasable programmable read-only memory (EPROM) and some drivers in a D-25 connector shell connected to the I/O port of either adapter **32** or the client. With a dongle security system key installed, users can make as many communications or "copies" of the data as they want but must respond with the dongle's programmed validation code for each copy, thereby accounting for each copy made. To allow daisy-chained dongles, the dongles can be designed to pass data through the I/O port and to monitor for magic codes (and combinations of status lines) with little interference to devices further down the line.

Burst controller **84** of MAC & Client Interface section **80** is a time division multiple access (TDMA) scheme that supports both isochronous and asynchronous data through burst control as well as accounts for high interrupt latency on the PC. Isochronous service guarantees the reserved bandwidth while asynchronous service

provides a conventional LAN type of service that is ideal for data sharing applications.

II. Baseband Section

From MAC & Client Interface section **80**, the digital data is communicated to Baseband section **90** that is part of broadband ASIC **78**. In Baseband section **90**, the data is encoded and modulated.

To encode the data, Forward Error Correction (FEC) encoder **92** is used. Preferably, FEC encoder **92** is a Reed-Solomon Error Correction Code (R-S ECC) encoder. The advantage of using a RS ECC encoder is that the RS ECC encoder may be reused in the FEC decoder **94**, thereby dramatically reducing the complexity of syndrome calculation and thus reducing processing speed burden on the syndrome block. On interacting with FEC encoder **92**, parity bits (or bytes) are added to the data to permit detection of data that becomes corrupted in transit as well as permit correction of the same. Other bits that may be added include network control data that specifies the routing, content data that specifies the what is being transmitted, as well as other known parity bits.

Once through FEC encoder **92**, the data encounters modulator **96**. Modulator **96** remaps the digital data and presents the data in an analog wave form to permit the data to be transmitted within the coaxial cable. It is important for cable LAN adapter **32** to be screened from noise and hardy enough to work in any environment while remaining inexpensive. Thus, in order to keep costs low and the system robust, the architecture design of adapter **32** uses a digital modulation scheme such as Frequency Shift Keying (FSK) modulation or Binary Phase Shift Keying (BPSK) modulation. Moreover, although data may be transmitted within the coaxial cable continuously, discontinuously, or a combination thereof, modulation is done

preferably in a discontinuous, burst fashion to accommodate network type data with minimum receiver setup time. Other acceptable modulation schemes include Quadrature Phase Shift Keying (QPSK) digital modulation.

III. RF & Mixed Signal Section

From Baseband section **90**, the data encounters Radio Frequency (RF) and Mixed Signal section **100**. The RF & Mixed Signal section consists of a complementary metal-oxide semiconductor (CMOS) RF chip **102**, crystal oscillator **104**, and crystal oscillator **106**. Crystal oscillator **104** and crystal oscillator **106** generate the clock that runs CMOS RF chip **102**. As shown in **Figure 4**, CMOS RF chip **102** comprises mixed-signal section having digital to analog converter (DAC) **108** and analog to digital converter (ADC) **110**, up converter **112** and down converter **114**, power amplifier (PA) **116** and a low noise amplifier (LNA) **118**, and Low (LO) frequency synthesizer (SYN) timing circuit **120** that couples the converters to their respective amplifiers through mixer **122**.

Within DAC **108**, the digital data from modulator **96** is converted to an analog signal having an intermediate frequency (IF) of around 44 MHz. To bring the signal operating frequency to the desired transmitting frequency, here 1300 MHz as seen in **Figure 3**, the analog signal is processed by up converter **112**. Up converter **112** generates a carrier modulated digital signal on which to transmit client data through the coaxial cable network. The power is amplified in PA **116**, wherein the signal is then sent to Medium Interface section **130**.

IV. Medium Interface Section

In accordance with an embodiment of the invention, Medium Interface section **130** interfaces with cable wire **24** through switch **132** that operates to either

transmit or receive signals. A single pole double throw (SPDT) transmission switch would accomplish this. Through switch **132**, the signal is transmitted into cable wire **24**. Although **Figure 4** shows a one signal frequency design channel, more than one signal frequency may be used.

With the signal transmitted from a first adapter **32**, at least a designated second adapter **32** will receive the signal. On receiving the transmitted data through cable wire **24**, second adapter **32** reverses the process by converting the transmitted data into a form usable by a second client and transmitting that data to that client. From switch **132** of **Figure 4**, LNA **118** focuses the signal so that down converter **114** may convert the signal to an intermediate frequency (IF) of around 44 MHz. The analog signal is then converted to a digital signal in ADC **110**.

At this point in the process, filtering may be necessary. As the signal travels within the coaxial cable network, reflection from low pass filter **18** may compensate for signal attenuation due to splitters in the coaxial cable network, but may also cause a reflection mismatch between the signal and the reflected signal. Filters within Baseband section **90** filter out such reflected signals. From there, the signal is a demodulated at demodulator 9~~4~~8 with the data then being decoded and corrected at FEC decoder **94**. The digital data is then sent to the second client through MAC & Client Interface section **80**.

A specific embodiment of the cable LAN according to the invention has been described for the purpose of illustrating the manner in which the invention may be made and used. It should be understood that implementation of other variations and modifications of the invention and its various aspects will be apparent to those skilled in the art, who may develop a variation of structural details without departing from the principles of the present invention. For example, the

components of the cable LAN adapter, either individually or in combination, can be housed in an integrated circuit. The cable LAN has been describe in reference to use in a private home, but may be used for any enterprise that has cabling equal to or superior than that found in a typical private home, including a small office/home office (SOHO).